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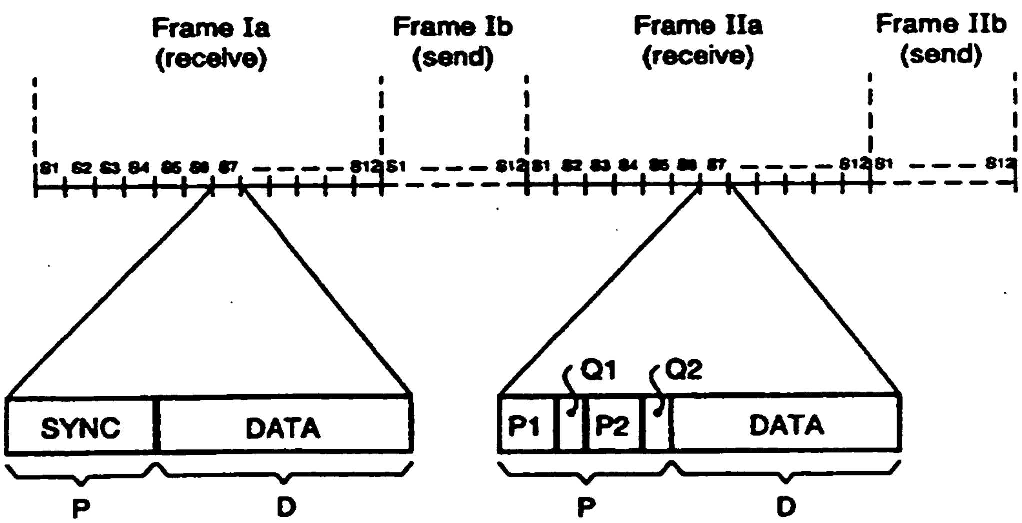

(57) Abstract

A method of selecting in a DECT-type radio communications system in which the mobile stations have antenna diversity, i.e. two antennas (A1, A2), that antenna which will provide the best reception quality (e.g. the smallest bit error rate). The radio system transmits the messages, which include a preamble, i.e. an introductory part (P), prior to the actual message information (D). This message preamble includes a specific bit pattern 01010101... and can be used to synchronize the receiver of the mobile station. According to the proposed method, the bit pattern is divided into two parts (P1 and P2). Upon receipt of the message, the first part (P1) is used to assess the reception quality of one antenna and the second part (P2) is used to assess the reception quality of the second antenna. The measured qualities are then compared and that antenna which is found to have the best reception quality is selected to receive the following information message (D).

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A method in a diversity receiver

TECHNICAL FIELD

The present invention relates to a method of selecting an antenna from two (or possibly more) antennas available in a diversity receiver. This diversity receiver may form part of a transceiver unit in a mobile station intended for a DECT-type radio system, i.e. for a cordless person communication system of relatively short range, although with the possibility of a mobile subscriber roaming over a large area.

DESCRIPTION OF THE PRIOR ART

The range between a base station and associated mobile stations is an essential criterion, particularly in systems of aforementioned kind, with regard to obtaining a cost-effective base station infrastructure and also with regard to obtaining a broad coverage radio system.

The power of a transmitted radio signal is typically inversely proportional to the fourth power of the distance between the transmitter and the receiver. Thus, the area covered by the base station will be doubled with each 6 dB increase in receiver sensitivity, therewith enabling the number of base stations required to cover a large given area to be reduced by 50%.

The total cost of the system can also be greatly reduced, by improving receiver sensitivity.

By sensitivity is meant here the minimum field strength at the receiver antenna which gives acceptable speech quality. For instance, there is described in "The Performance of DECT in the Outdoor 1.8 GHz Radio Channel" by L.B. Lopes and M.R. Heath, University of Leeds and BT Laboratories UK, a DECT

system which operates in accordance with the TDMA technique, in which the sensitivity limit is set to 1% burst error, i.e. only one burst in one-hundred may be in error (which is the same as saying that the so-called CRC error may be at most 1%).

The use of antenna diversity on the transmitter side or the receiver side will result in a marked improvement in sensitivity, with low cost in regard of typical fading environments in a radio system. Antenna diversity involves separating two antennas in space or giving the two antennas different polarizations, so that a choice can be made between two radio paths, it being highly improbable that both paths will have a deep fading dip at one and the same time, i.e. that the signal strength will be low in both paths at one and the same time, because of fading.

Figure 10 in the aforesaid reference shows that the antenna diversity can result in a sensitivity increase of 10 dB (at 1% CRC error probability).

The aforesaid reference also discloses that the antenna path to be used is controlled by two different conditions. With one receiver for each of the two antennas, the control is performed after detection by comparing the quality of the two links for each burst, and data is selected from that link which had the best quality. A less costly implementation is to have only one receiver together with a switch for the two antennas, wherein when the quality of a received burst is too poor, the receiver is switched to the other antenna for receiving the next burst.

In the DECT system described in the aforesaid reference, the time lapse between two consecutive bursts is 10 ms. The time taken to decide that the old antenna is poor and to change to the other antenna is therefore 10 ms.

Figure 13 in the aforesaid reference shows that the simple diversity with a 10 ms switching delay is effective when mobile stations are stationary or move only very slowly. However, when the speed of the mobile station increases the diversity gain may be lost, because the mobile station will travel so far during the 10 ms period that an estimation of the radio path will no longer be of any assistance. The more expensive 2-radio post selection diversity gives a sensitivity gain of 10 dB, irrespective of the speed at which the mobile station moves.

SUMMARY OF THE INVENTION

The aforesaid decision time, 10 ms in the case of the DECT system, is relatively long and the propagation conditions (fading, time dispersion) for a quickly moving mobile station are able to change during this period. It is, therefore, possible that the decision reached will be the wrong decision, meaning that detection of the actual information message will be made by the antenna which gives the poorer quality.

The present invention relates to a method of the kind defined in the introduction which combines the aforesaid cost-effective method, according to which only one receiver is used in diversity reception, with the aforesaid two-receiver principle, which provides reception properties that are independent of speed.

According to the present invention, there is chosen a method of using a given predetermined control word, for instance a synchronizing word, immediately prior to the actual message that contains the information to be detected, in order to test which of the two antennas of the receiver is best suited for this detection. This greatly improves the likelihood of the best antenna being chosen when receiving the message.

Thus, it is the object of the present invention to provide a method of selecting or determining which of the two antennas in a diversity receiver will provide the best reception of an information message that immediately follows this determination or selection of the optimal antenna.

The inventive method is characterized by the method steps set forth in the following Claims.

BRIEF DESCRIPTION OF THE DRAWING

The invention will now be described in more detail with reference to the accompanying drawing, in which

Figure 1 is a block diagram illustrating a transmitter and a receiver with diversity in a radio communication system; and

Figure 2 is a diagram which illustrates frames and time slots and shows the configuration of messages transmitted in a TDMA system, with the intention of explaining the inventive method.

BEST MODES OF CARRYING OUT THE INVENTION

Figure 1 is a block diagram illustrating a transmitter S and a receiver M having diversity in a radio communication system, for instance in a DECT system in accordance with the aforegoing.

The transmitter S may be included in the transmitter-receiver unit of a base station and is comprised of known components and circuits. The transmitter sends radio signals in accordance with the TDMA principle, i.e. short bursts of control information and message information within given time slots in accordance with the following description. Each signal time-divided in the transmitter S is comprised of a burst in a given time slot intended for a given receiver, and the

bursts are transferred in a known manner, by suitable modulation and by means of a carrier wave having a given allotted frequency within the GHz range.

The receiver M is included in a mobile station which communicates with or which shall communicate with the base station. The receiver has two antennas A1 and A2, which, in the illustrated case, are connected to only one detector unit in the receiver M, by means of a switch SW. The receiver detector is thus common to both of the antennas A1 and A2. The switch SW is controllable and is switched between its two positions by the detector unit in dependence on the quality of a burst from the radio signals sent by the transmitter S, this quality being determined by the detector unit. The bit error rate BER of the detected bursts, the C/I ratio or some other known measurement may be used as a quality determining factor.

Figure 2 is a time diagram over frames Ia, Ib, IIa, IIb... and time slots S1...S12 within each frame that defines the so-called physical channels in a TDMA system, in this case particularly a DECT system. Transmission and reception for both a base station and a mobile station are organized so that each alternate frame is a transmission frame and each other alternate frame is a reception frame. Each frame contains a given number of time slots, in the DECT system 12 time slots S1...S12. In the DECT system, the time interval of a transmission frame Ia and a reception frame Ib is 10 ms.

In the DECT system, a time slot, e.g. S7, is about 0.4 ms (24 time slots in a 10 ms frame). In order to obtain a radio link which is essentially constant during the reception of a 0.4 ms data packet, the distance travelled by a subscriber during the 0.4 ms period must be short in comparison with the distance in space between the fading dips. The distance between the fading dips is about 8 cm at 1.9 GHz, and short relative distances are <10%, i.e. <8 mm. Thus, the movement speed shall be

maximum 20 m/s (72 km/h) in order for the subscriber not to move further than 8 mm in the 0.4 ms period. The antenna selection diversity is thus also effective in the case of vehicle-carried DECT. Technology in which antenna selection diversity shall be effective at a walking speed (1 m/s) may therefore not receive on the same antenna for a period which is greater than 8 ms (20 x 0.4 ms). In other words, the time slot during which the same antenna is used for receiving purposes must be shorter than 8 ms, otherwise the diversity will only provide a gain for stationary reception, (in which case the cheap standard diversity in DECT which provides no gain when the subscriber moves might just as well be used, (see from line 16 on page 2 to line 7 on page 3).

Transmission from the base station - reception in the mobile station take place in the frame Ia, while a burst is received in, e.g., time slot S7 within said frame, as shown in Figure 2.

Transmission from the mobile station and reception in the base station take place in frame Ib. This is ignored in the present case, however, which deals solely with transmission base station-mobile station. The invention may, of course, also be applied in this case in accordance with the same principle.

Transmission from the base station - reception in the mobile station again takes place in frame IIa, similar to frame Ia, although detection in the receiver is different, as made evident below. Transmission and reception take place in frame IIb, similar to frame Ib.

In the Figure 2 illustration, the transfer between the base station and the mobile takes place in time slot S7, wherein the mobile station will receive bursts from the base station in time slot S7 in each frame Ia, IIa... until reception has been terminated. However, handover can take place when a new

channel is chosen by or allocated to the mobile station, whereafter the transfer may be made in a time slot other than the earlier mentioned time slot S7. Channel allocation in the DECT system is also dynamic, in other words the mobile station chooses from the total number of available channels that channel which is free at that moment in time and which has the lowest signal interference ratio C/I.

Figure 2 shows a burst within a time slot S7. The burst includes a preamble P which may have a length of 10 bits. This is followed by the actual information part D. This division of a message is generally known in the DECT system.

As is known, the message preamble P is used as a control message or as a synchronizing word for the receiver, and more particularly for its detector. A synchronizing word may consist of alternate ones and zeros, for instance 01010101... (10 bits). In this regard, the detector in the receiver M can synchronize itself to the following data message D.

According to the present method, the synchronizing word is divided into two parts P1 and P2 so as to enable the detector in the receiver M to perform a quality measurement of the signals from each of the two antennas A1 and A2 during a respective time interval P1 and P2. An interval Q1 and Q2 between P1, P2 and between P2 and the data message D respectively are also reserved for switching of the switch SW between the two antennas A1, A2.

It is assumed initially that when reception is started after channel allocation and activation in a known manner from the base station transmitter in response to the reception and detection of the synchronizing word, the switch will be positioned so that antenna A1 is connected to the receiver detector, as illustrated in Figure 2. The receiver detects the incoming synchronizing word, in the present case

01010101..., during the whole of the interval P, with the intention of ascertaining whether or not reception over the chosen channel is at all possible. It may happen that reception over the chosen channel is poorer than if the receiver had instead been set to receive over the antenna A2, although in order for reception of the entire burst to be acceptable it should be possible for the receiver to detect the synchronizing word over the poorest antenna, since it is easier to detect the synchronizing word correctly (gives less bit errors) than it is to detect the subsequent data message. The inventive method is not a method of solely detecting a message by means of diversity, but a method of obtaining the best possible quality of a detected message when receiving with antenna diversity.

Thus, it is assumed in the following that the receiver has detected the synchronizing word (01010101...) during the interval P by means of the antenna A1, even though a connected antenna A2 would have given a better detection result during precisely the synchronization part of the signal (frame Ia). The receiver detector has therewith detected the start time point of the preamble P in each burst.

During the next reception frame IIa, time slot S7, the receiver is still connected to the antenna A1 and the detector therewith detects and measures the reception quality of the synchronizing word received during the interval P1. Upon completion of this procedure, the antenna A2 is connected to the receiver detector for similar detection of the synchronizing word, although this time during the interval P2. A given small time interval Q1 can be reserved during the interval P to enable switching of the antennas to be effected prior to said detection procedure and to ensure that the antennas will be switched at the correct instant with regard to the bit pattern of the synchronizing word.

The receiver detector detects and determines the reception quality of the synchronizing word received during the interval P2 in accordance with the same criterion as that used to determine the reception quality of the synchronizing word received during the interval P1. A comparison of the two measured qualities is then made during an interval Q2, which has been reserved for this purpose and for possible switching of the switch SW back to the antenna A1.

If it is assumed that the reception qualities determined in the intervals P1 and P2 are respectively referenced QM1 and QM2, the comparison and decision are made in accordance with the following:

Antenna A1 is connected

If QM1 > QM2, no switching is made to antenna A2.

If QM1 < QM2, switching is made to the antenna A2 during the interval Q2.

Antenna A2 is connected

If QM1 > QM2, a switching is made to antenna A1 during the interval Q2.

If QM1 < QM2, no switching is made.

Thus, the conditions for proceeding in accordance with the inventive method are:

a) The presence of a control method (synchronizing word) having a regular and specific bit pattern, so that division of the two intervals P1 and P2 can be made and so that equal determination of reception quality can be performed.

b) The presence of the control message at the beginning of the actual message that shall be received with improved reception quality.

The inventive method can also be applied with analog radio systems having antenna diversity if the system transfers messages that have windows with short time intervals, where no traffic information is found. Such a window can, therefore, be used in accordance with the method to contain the two part intervals P1 and P2 in accordance with the aforegoing.

CLAIMS

1. A method of selecting a given antenna from two available antennas (A1, A2) in a diversity receiver which is included in a radio system and which is connected to the first (A1) of said antennas, wherein the radio messages to the receiver are transferred and received within a given time slot in mutually sequential frames (Ia, IIa...), wherein each message includes a preamble (P) and a data/information part (D), and wherein the preamble is comprised of a regular bit pattern (010101...) known to the receiver, **characterized** in that
a) the radio receiver receives the preamble (P) over said first said antenna (A1) and determines or assesses the reception quality of said bit pattern during a first time interval (P1) of said message preamble;
b) the radio receiver is switched (SW) to the second (A2) of said two antennas and determines or assesses the reception quality of said bit pattern during a second time interval (P2) of said message preamble (P); and
c) the radio receiver compares the determined reception qualities and chooses the antenna that exhibited the highest reception quality to receive the data/information part (D) of said message.

2. A method according to Claim 1, **characterized** in that the criterion to be used in determining reception quality is established prior to determining the reception quality of said first and second parts of the message preamble and comparing these qualities, by virtue of being able to establish in the frame which precedes the frame in which said quality determination is effected the location of said message in a time slot, so that the method can be carried out.

3. A method according to Claim 1, **characterized** in that the message preamble is comprised of a synchronizing pattern which is intended for radio transmission and which is intended for

use in synchronizing the receiver to the information contained in the transmitted message.

4. A method according to Claim 3, **characterized** in that said synchronizing pattern is comprised of a sequence 010101....

Fig. 1

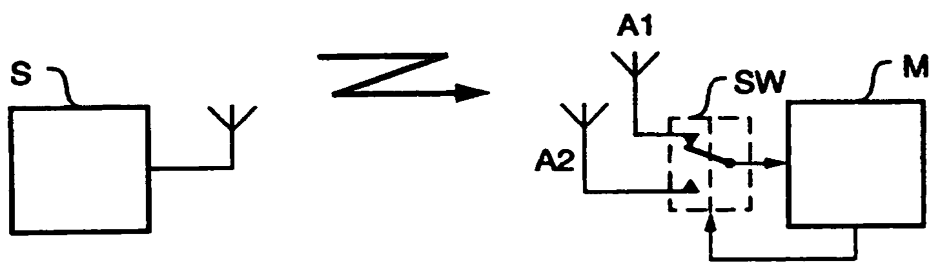
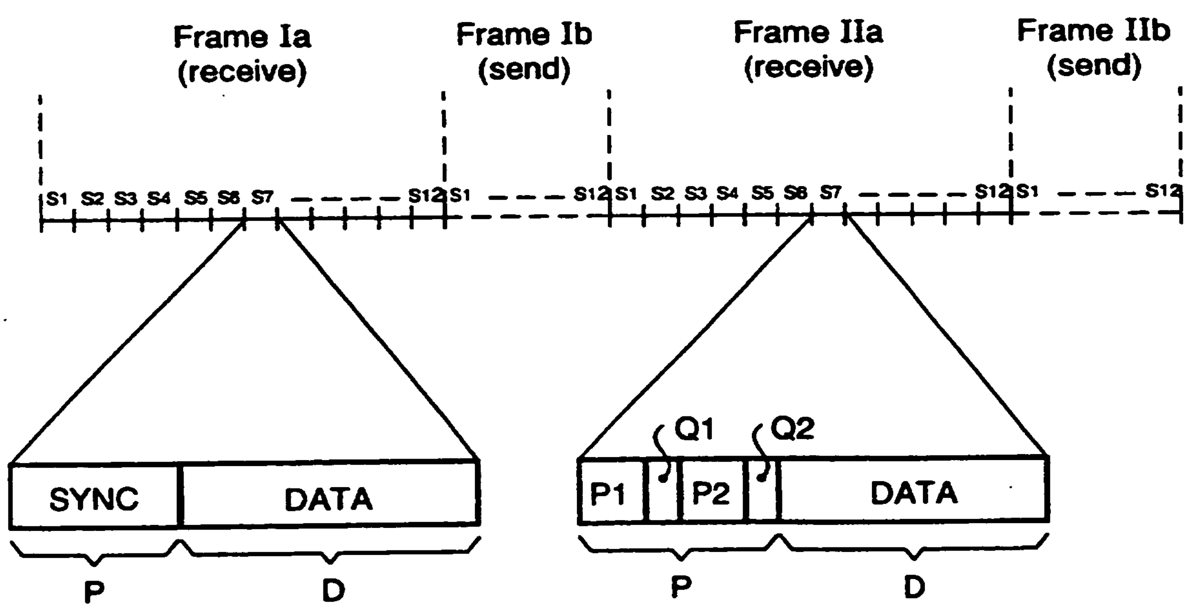

S
A1
SW
M
A2

Fig. 2


Frame Ia
(receive)
Frame Ib
(send)
Frame IIa
(receive)
Frame IIb
(send)
S1 S2 S3 S4 S5 S6 S7 S12 S1 S12 S1 S2 S3 S4 S5 S6 S7 S12 S1 S12
SYNC
DATA
P
D
Q1
Q2
P1
P2
DATA
P
D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/00786

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 7/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9415411 A1 (MOTOROLA, INC.), 7 July 1994 (07.07.94), page 8, line 35 - page 9, line 9, figures 3,5,6, abstract	1,3,4,
Y		2
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X	WO 9408404 A1 (NORTHERN TELECOM LIMITED), 14 April 1994 (14.04.94), page 3, line 4 - line 16, figures 5-6, abstract	1,3-4
Y		2
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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29 November 1995	29 -11- 1995
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/00786

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim N
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A		1,3-4
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INTERNATIONAL SEARCH REPORT
Information on patent family members

30/10/95

International application No.
PCT/SE 95/00786

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WO-A1- 9415411	07/07/94	NONE	
WO-A1- 9408404	14/04/94	NONE	
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WO-A1- 9410764	11/05/94	NONE	